

## PATENT CLAIMS

1. A digital X-ray scanning apparatus (1) comprising an X-ray source (2), an X-ray collimator (3), an X-ray detector (14), mounting means (9-11) for mounting the X-ray detector (14), scanning means (12, 7) for scanning (8b, 27) the X-ray detector (14) over an area (5), means (16) for digital data acquisition from the X-ray detector (14) and a control unit (2c) for steering the X-ray apparatus (1), characterized in that
- 5 a) the mounting and scanning means (9-12, 7) comprise additional means (13, 15) for orienting (8c) the X-ray detector (14) in at least one dimension towards the X-ray source (2) during a digital scanning procedure,
- 10 b) wherein an orienting movement (8c) and a scanning movement (8b, 27) are independent degrees of freedom of the X-ray detector (14) and
- 15 c) the X-ray apparatus (1) is designed for steering the orienting movement (8c) of the X-ray detector (14) in coordination with the scanning movement
- 20 (8b, 27) of the X-ray detector (14).
2. The X-ray apparatus (1) according to claim 1, characterized in that
- 25 a) the mounting and scanning means (9-12, 7) comprise translational means (11, 12) for moving the X-ray detector (14) along a straight line segment (8b, 27) or along a curved or circular line segment and/or
- 30 b) the additional means (13, 15) comprise rotational means (13, 15) for tilting (8c) the X-ray detector (14) in order to maintain a constant aspect ratio of the X-ray detector (14) as viewed from the X-ray source (2) and/or
- 35 c) the X-ray detector (14) is a single- or multi-line digital X-ray detector (14).

3. The X-ray apparatus (1) according to claim 2, characterized in that

- 5 a) the translational means (11) is a carriage (11) that is movable in a direction perpendicular to its lateral extension,
- b) the rotational means (13) is a rotatable plate (13) that is mounted on the carriage (11) and is designed for receiving the X-ray detector (14), and
- 10 c) in particular that the rotatable plate (13) is laterally extended for receiving an elongated single-line digital X-ray detector (14) suitable for partial or full body X-ray scanning (8a, 8b, 27).

4. The X-ray apparatus (1) according to one of the claims 2-3, characterized in that

- 15 a) a housing (10) for receiving the translational and rotational means (11, 13) is provided, which housing (10) can be kept stationary during the scanning movement (8b, 27) and
- b) in particular that the mounting and scanning means (9-12, 7) comprise means (9, 7) for repositioning the housing (10) for different scanning procedures.
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5. The X-ray apparatus (1) according to one of the previous claims, characterized in that

- 25 a) means for swiveling (8d) the X-ray source (2) and the collimator (3, 3a) in coordination with the scanning movement (8b, 27) and orienting movement (8c) of the X-ray detector (14) are provided and
- b) in particular that a balanced suspension of the X-ray source (2) and the collimator (3, 3a) for a torque-free swiveling movement (8d) is provided.
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6. The X-ray apparatus (1) according to one of the previous claims, characterized in that

- 35 a) a motor drive unit (15) and mechanical coupling means (23) are provided for synchronously driving the scanning movement (8b, 27) and the orienting

movement (8c) of the X-ray detector (14) and a translational or swiveling movement (27; 8a, 8d) of the X-ray source (2) or

5 b) several motor drive units (15) and an electrical control means (2c) for driving and synchronizing the scanning movement (8b, 27) and the orienting movement (8c) of the X-ray detector (14) and a translational or swiveling movement (27; 8a, 8d) of the X-ray source (2) are provided and

10 c) in particular that sliding clutches are provided between the at least one motor drive unit (15) and moving parts (2, 3, 4, 9, 10) of the X-ray apparatus (1).

9 7. A digital X-ray scanning apparatus (1) ~~in particular~~ according to one of the previous claims, comprising an X-ray source (2), an X-ray collimator (3), an X-ray detector (14), mounting means (9-11) for mounting the X-ray detector (14), scanning means (12, 7) for scanning (8b, 27) the X-ray detector (14) over an area (5), means (16) for digital data acquisition from the X-ray detector (14) and a control unit (2c) for steering the X-ray apparatus (1), wherein additional photographic X-ray imaging means (2, 3, 4) comprising a cassette holder (4) for photographic films are provided, characterized in that

25 a) the mounting means (9-11) comprise a housing (10) that is designed for receiving the X-ray detector (14) and the cassette holder (4) in such a way that the X-ray detector (14) and the photographic film are facing towards different side faces of the housing (10) and

30 b) the mounting means (9-11) are designed for performing a reorienting movement (8z) of the housing (10) such that either the film cassette (4) or the X-ray detector (14) is positioned for X-ray imaging.

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8. The X-ray apparatus (1) according to claim 7, characterized in that

a) the housing (10) is adapted for receiving the X-ray detector (14) on a front side (24) and the cassette holder (4) on a back side (25) and

b) the mounting means (9-11) has an axis (z) for rotating the front side (24) or the back side (25) of the housing (10) towards an X-ray source (2).

9. The X-ray apparatus (1) according to one of the claims 7-8, characterized in that

a) the same X-ray source (2) is used for both digital and photographic X-ray imaging and/or

b) the X-ray collimator (3) is removable or a slit (3a) is openable for photographic X-ray imaging and/or

c) the X-ray collimator (3) or the slit (3a) is steered automatically, in particular by a sensor indicating the presence of a photographic film in the cassette holder (4) and/or by a switch in the cassette holder (4) and/or by a sensor indicating an orientation of the housing (10) for either digital or photographic X-ray imaging and/or by a manual switch and/or by means of software.

10. A digital X-ray scanning apparatus (1) ~~in particular~~ according to one of the previous claims, comprising an X-ray source (2), an X-ray collimator (3), an X-ray detector (14), mounting means (9-11) for mounting the X-ray detector (14), scanning means (12, 7) for scanning (8b, 27) the X-ray detector (14) over an area (5), means (16) for digital data acquisition from the X-ray detector (14) and a control unit (2c) for steering the X-ray apparatus (1), characterized in that the mounting means (9-11) are designed such that the X-ray detector (14) is held in a position shifted towards an anode side (2a) of the X-ray source (2) by an angle  $\alpha$ , wherein  $0^\circ < \alpha < \beta$  with  $\beta$ =anode angle.

11. The X-ray apparatus (1) according to claim 10, characterized in that

a) the positioning angle  $\alpha$  is chosen around  $\beta/2$ ,

b) in particular that  $4^\circ < \alpha < 12^\circ$ , preferably  $\alpha = 6^\circ$  with  $\beta = 12^\circ$ .

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93 12. The X-ray apparatus (1) according to one of the previous claims, characterized in that the X-ray collimator (3) has an opening (3b) for photographic imaging and comprises at least one movable shutter (19a) with a built-in collimator slit (3a) to provide a precisely collimated beam (26a) for digital X-ray scanning.

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13. The X-ray apparatus (1) according to claim 12, characterized in that

a) the X-ray collimator (3) comprises two pivoted shutters (19a, 19b) and/or

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b) the X-ray collimator (3) comprises a turning knob (18) to open or close a shutter (19a, 19b) and/or

c) a shutter (19a) has means (20) for adjusting a position of the slit (3a) and/or a width  $y$  of the slit (3a) in a range  $0.2 \text{ mm} < y < 5 \text{ mm}$  and/or

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d) the X-ray collimator slit (3a) is positioned in a fixed distance from the X-ray source (2).

14. The X-ray apparatus (1) according to one of the previous claims, characterized in that

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a) the X-ray detector (14) is a single- or multi-line X-ray detector (14) with X-ray sensitive elements and

94 b) in particular that the X-ray sensitive elements comprise scintillator crystals and optical detectors, that are connected to at least one A/D converter and to a microcomputer (16) for serial read-out.

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15. The X-ray apparatus (1) according to claim 14, characterized in that the X-ray detector (14) has means for gain and/or offset correction of analogue signals from each X-ray sensitive element and/or from the whole detector (14).

16. The X-ray apparatus (1) according to one of the previous claims, characterized in that

a) the X-ray detector (14) has a digital signal processor for detector control and data acquisition and/or

b) the X-ray detector (14) has a digital memory for data acquisition and data storage.

95 15 17. The X-ray apparatus (1) according to one of the previous claims, characterized in that for full or partial body digital X-ray imaging distance ranges  $900 \text{ mm} < d_1 < 1450 \text{ mm}$ ,  $500 \text{ mm} < d_2 < 900 \text{ mm}$  and  $10 \text{ mm} < d_3 < 200 \text{ mm}$  are provided, where  $d_1$ =distance between the X-ray source (2) and the X-ray detector (14),  $d_2$ =distance between the X-ray collimator slit (3a) and the X-ray detector (14) and  $d_3$ =distance between the patient (5) and the X-ray detector (14).

18. The X-ray apparatus (1) according to one of the previous claims, characterized in that

a) a supporting arm (9) for carrying the X-ray source (2), the X-ray collimator (3) and a housing (10) for the detector (14) is provided and

b) the supporting arm (9) is rotatable and the X-ray source (2) together with the X-ray collimator (3) and the housing (10) for the detector (14) are tiltable with respect to the supporting arm (9) in order to position the X-ray source (2), the X-ray collimator (3) and the detector (14) for X-raying a standing, sitting or lying patient (5).

c) the supporting arm (9) is rotatable by at least 90° in order to switch between X-raying a standing or sitting and a lying patient (5).